PATENT SPECIFICATION
DRAWINGS ATTACHED

824931

Date of Application and filing Complete Specification Jan. 4, 1956.
No. 294/56.
Application made in Czechoslovakia on Jan. 6, 1955.
Complete Specification Published Dec. 9, 1959.

Index at acceptance:—Class 80(2), S2(B3:E).
International Classification:—F06d.

COMPLETE SPECIFICATION

A Permanent Coupling between Two Rotatable Members

We, ZÁVODY V.I. LENINA, NÁRODNÍ PODNIK, of Plzen, Czechoslovakia, a Czechoslovak National Corporation, and SAVELIJ CHADZÍ, of Plzen, Czechoslovakia, a Czechoslovak Citizen, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In general engineering, various permanent connections between two machine elements are known for transmitting turning movements. The most usual connections of this kind are couplings between two shafts.

In the simplest cases, the shafts are provided with flanges which are connected together by a number of fitted-in bolts and nuts. These bolts have the functions of pressing the flanges together in an axial direction and more particularly of transmitting the torque; they are therefore subjected to shearing stresses.

In other well-known couplings, the bolts are relieved of shearing stresses by a key inserted into grooves provided in the oppositely disposed flange faces. These connections are most frequently used in piece production of comparatively large machine elements which are only rarely disconnected from each other. Their machining requires accurate fitting of the elements to each other and, in most cases, they are not interchangeable. These connections transmit almost exclusively the tangential forces resulting from the turning moment and are not subjected to stress by axial forces.

In those cases where there is the necessity of dismantling the machine elements more frequently or where it is necessary in case of repetition production to shorten the time required for the assembling and dismantling operations, flange couplings are used wherein the oppositely disposed faces of the flanges are provided with transversely or radially extending tapered teeth.

Two examples of such couplings are shown in Figs. 1 and 2 of the accompanying drawings, each figure showing a lateral view of the coupling and a view of the coupling face of one of the two flanges.

As shown in Figs. 1 and 2, a shaft 6 is provided with a flange 7 and a shaft 8 with a flange 9, and the end faces of the two flanges which face one another are provided with teeth which engages each other. The flanges are held together by means of screw bolts 10 and nuts 11, a washer 12 being inserted between the nut and the adjacent flange. According to Fig. 1, the teeth 13 extend transversely of the shaft, whilst the teeth 14, shown in Fig. 2, are radially disposed.

Such couplings are well suited for repetition production since the assembly as well as the dismantling operations are easy to perform, and the coupling members can be easily interchanged.

The tangential forces resulting from the turning moment are transmitted in these couplings by the tooth flanks which are generally conical in shape. The axial forces resulting from the conicity of the teeth are taken up by the connecting bolts, the nuts of which are secured against loosening by the usual securing means, such as spring washers or lock nuts with cotters. The great number of tooth flanks, which have the function of transmitting the forces resulting from the turning moment, requires an extremely high precision in their machining. A theoretical precision which would enable the teeth to take part equally in the transmission of the turning moment, is beyond the possibilities offered by the most precise hitherto known machine tools with optical setting of the cutters.

In practice, therefore, it is not possible to form the teeth so that they engage each other over their entire flank face; as a rule only parts of co-acting flank faces will be in contact. Such reduction of the flank face con-

[Price ...]

Price

tact frequency results in overloading above the elastic limit of the material and in a deformation of the teeth within the limits corresponding to the difference between the theoretical and production precisions. The result is the formation of small clearances which continuously grow larger during operation and finally lead to loosening or to destruction of the connection.

However, not only lack of accuracy in the formation of the teeth is the cause of loosening the connection. The lack of precision in machining the threads both on the bolts and in the nuts, and likewise the elongation of the bolts under the influence of the axial forces may also lead to loosening of the connection.

The use of securing means of usual form only in order to avoid loosening of the bolts is inadequate in this case and does not guarantee that the connection will not become loose even if the bolts are not loosened. This fact has reduced to a considerable extent the use of permanent couplings having transverse or radial tapered teeth for the transmission of small torques, and so far as they have been used, uneconomically large couplings were used to safeguard against the loosening of the connection.

It is an object of the present invention to overcome the indicated difficulties. To this end, a permanent connection between two rotatable parts of a machine for the torque transmission, is characterised in that the two rotatable parts where they face one another are provided with complementary coupling faces, each provided with radially or transversely extending tapered teeth adapted to engage each other, the angle between the flank of each tooth and a normal on the root circle being smaller than 30°, that the two parts are held and pressed together by bolts and nuts or screws with a set or cambered washer between the head or nut and the adjacent part of the machine, and that the washer is made of a resilient steel and its set or camber is so dimensioned that it is the sum of the sets or cambers fAx plus fb plus fvs plus fvz as defined hereinafter. Consequently, when the nuts or screws are tightened and the washers become flattened as a result, they produce an axial force which is not only adequate for equalising the axial forces tending to separate both elements of the coupling from each other, but provide a sufficient reserve for maintaining the elements of the coupling in fixed connection even if any clearance should occur between the teeth or between the threads of the nuts and the connecting bolts resulting from elongation of the bolts.

For the definition of the total set or camber of the washers, reference will be made to the diagrams shown in Figs. 5 and 6 of the accompanying drawings, wherein Fig. 5 shows the force exerted on compression by the cambered washer plotted over the size of the camber, whilst Fig. 6 represents the shape of a tooth of the one coupling face and the corresponding groove between two teeth of the complementary coupling face.

The maximum axial force Amx to which the cambered washers are subjected is:—

$$Amx = Pmx \cdot \tan\beta = \frac{Mkmx \cdot \tan\beta}{\pi z}$$

wherein

$Mkmx$ = the maximum torque to be transmitted by the coupling;

πz = the mean radius of the toothing on the front face of each coupling member;

Pmx = the maximum tangential force corresponding to the maximum torque = $\frac{Mk\,mx}{\pi z}$

β = the angle between a tooth flank and a normal on the root circle and is smaller than 30° as shown.

The corresponding set or camber of the plate washer in respect of the axial force Amx is then fAx. It is desirable to introduce a safety factor and to increase the force Amx to Q^1 which means an increase of the set or camber by fb. Moreover, two further amounts of set or camber have to be added, i.e.

fvz = the set of the plate washer corresponding to the maximum possible clearance in the teeth owing to inaccuracy of manufacture and due to wear;

fvs = the set of the plate washer corresponding to loss of bolt tension and to the maximum possible clearance in the bolt threads owing to inaccurate machining;

which results in the total set or camber of fc of the plate washer. fvz and fvs are values based on design experience. The force Q corresponding to the total set or camber fc, i.e. the force produced by the plate washer after complete flattening can then be calculated from

$$Q = \frac{E}{(1-\nu^2)\alpha} \cdot \frac{fc\,s^3}{r_{vn}^2}$$ wherein

E = the modulus of elasticity,

fc = the total set or camber in cm.,

s = the thickness of the washer in cm.,

r_{vn} = the outer radius of the washer in cm.,

α = a coefficient depending on the ratio between the inside diameter and the outside diameter of the washer,

ν = Poisson's ratio.

As can be seen from the diagram in Fig. 5, the force Q is greater than the force Q^1, which in turn is greater than the force Amx.

$$Q > Q^1 > Amx$$

It follows that the permanent coupling by means of a front cross or radial toothing in accordance with the present invention is

characterised by its being secured against loosening due to the arrangement of plate washers, dimensioned for a force Q at a set *fc*.

Such dimensioning of the plate washers ensures that clearances resulting from inaccuracy of the teeth and the clearances resulting from inaccuracy of the bolt threads or from elongation of the bolts, will be eliminated by the resilient plate washer, which will then change from its completely flattened state into a partially cambered or dished state, as required.

Thus, the force which the plate washer exerts will be somewhat reduced, but it is capable of equalising the axial forces resulting from the maximum torque to be transmitted by the coupling.

It will be obvious that in those cases where the coupling by means of tapered front teeth is provided with several connecting bolts, the plate washer under the head of each bolt is calculated for the force applied to one of the bolts.

Figs. 1 and 2 of the accompanying drawing show plate washers 12 which will be dimensioned as above stated.

Figure 3 illustrates a front view and a longitudinal view partly in section of a coupling by means of transversely disposed tapered teeth 2^1 between a cardan shaft 1 and a flat driving member 2 of a resilient coupling for the torque transmission from a motor to a gearbox.

In this case, the connection between the cardan shaft and the driving member 2 is provided by a single hollow screw 3 which is screwed into a threaded axial bore provided in the reinforced end of the cardan shaft. The cavity of the hollow screw has a hexagonal cross section for the insertion of a tightening tool. Under the head of the screw 3 is placed a plate washer 4 of a shape and size calculated in accordance with the present invention. The screw 3 is secured against inadvertent rotation by a securing ring 5 which is expanded into axial recesses.

Fig. 4 shows, for the sake of clarity, on an enlarged scale the coupling members according to Fig. 3.

It will be appreciated that the present invention solves in a new and advantageous manner the problem of a safe permanent connection between two machine elements for the transmission of a turning moment by means of transverse or radial toothing with tapered teeth, whereby the utility of this type of coupling is substantially increased. This new permanent connection for transmitting the turning moment has a wide field of application and can be used to particular advantage in electric locomotives for transmitting the turning moment from the traction motor through a flexible cardan joint to a pinion of the gearbox mounted on the wheel axle.

WHAT WE CLAIM IS:—

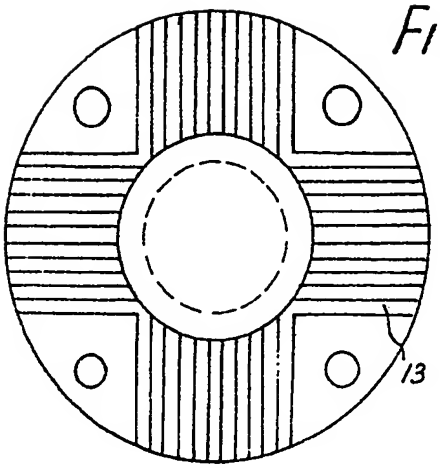
1. A permanent connection between two rotatable parts of a machine for the torque transmission, characterised in that the two rotatable parts where they face one another are provided with complementary coupling faces, each provided with radially or transversely extending tapered teeth adapted to engage each other, the angle between the flank of ach tooth and a normal on the root circle being smaller than 30°, that the two parts are held and pressed together by bolts and nuts or screws with a set or cambered washer between the head or nut and the adjacent part of the machine, and that the washer is made of a resilient steel and its set or camber is so dimensioned that it is the sum of the sets or cambers *fAx* plus *fb* plus *fvs* plus *fvz* as defined in the body of the specification.

2. A permanent coupling between two rotatable parts substantially as described with reference to and as illustrated in Fig. 1 or Fig. 2 or Figs. 3 and 4 of the accompanying drawings.

For the Applicants,
MATTHEWS, HADDAN & CO.,
Chartered Patent Agents,
31—32, Bedford Street, Strand,
London, W.C.2.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1959.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

FIG. 1.



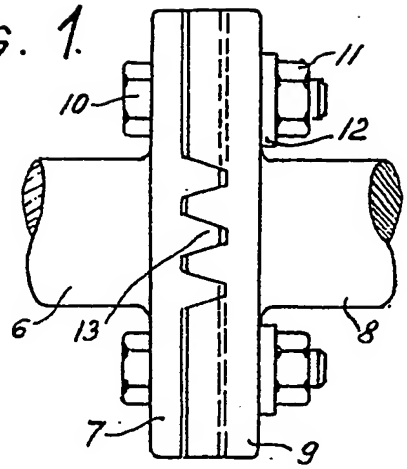
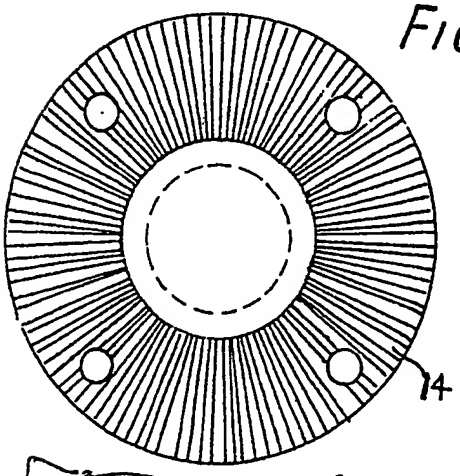
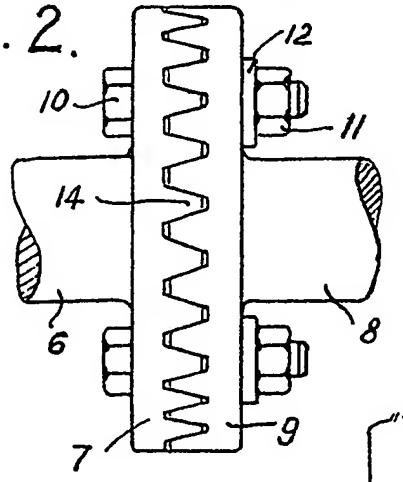


FIG. 2.





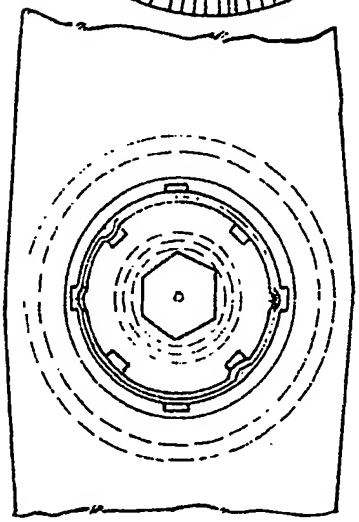
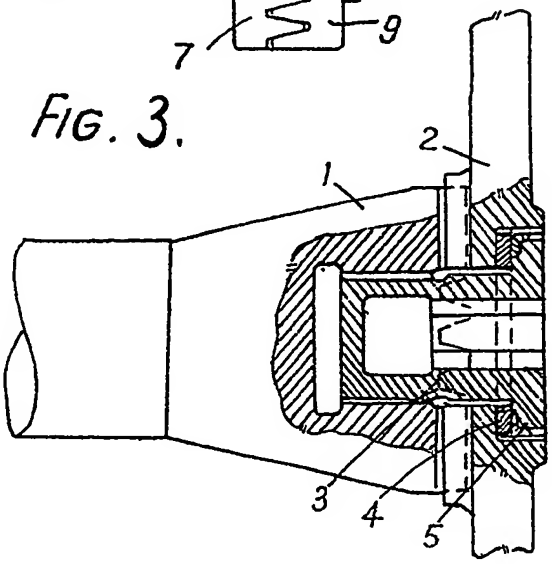


FIG. 3.



824,931 COMPLETE SPECIFICATION
2 SHEETS

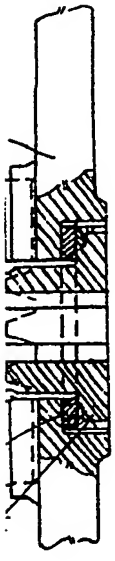


FIG. 4.

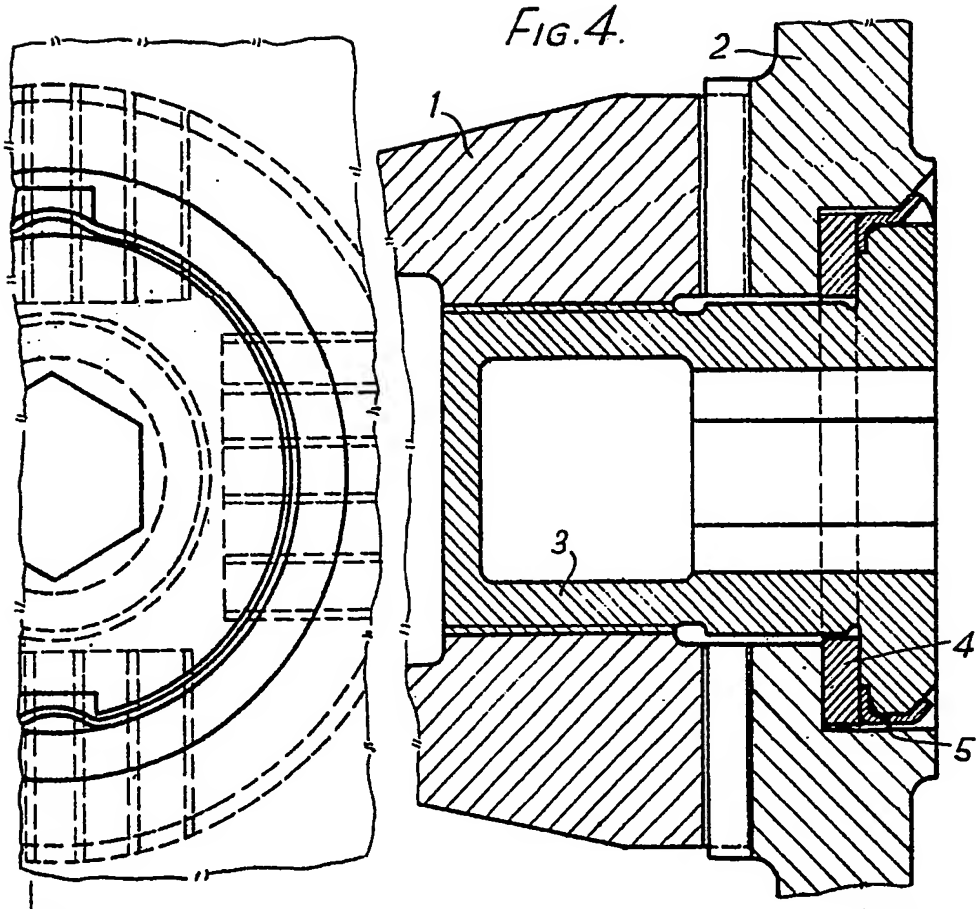


FIG. 5.

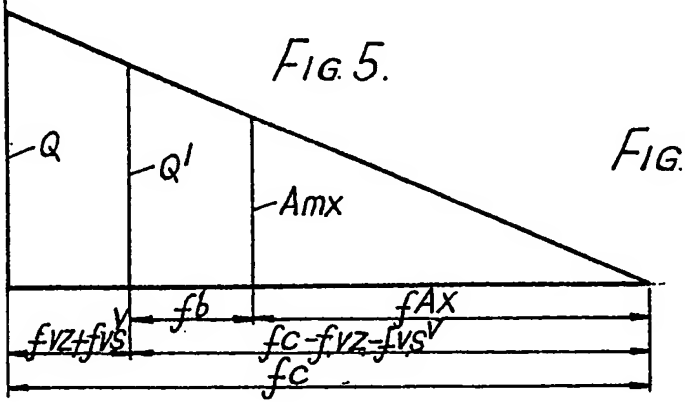
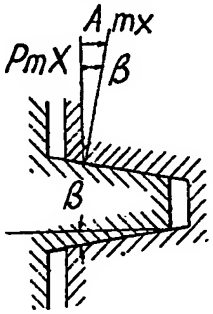


FIG. 6.



824,931 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

FIG. 1.

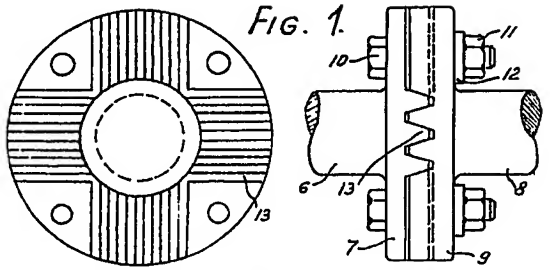


FIG. 2.

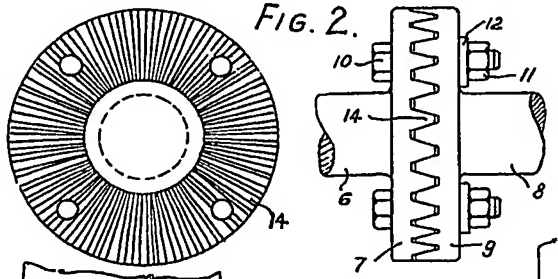


FIG. 3.

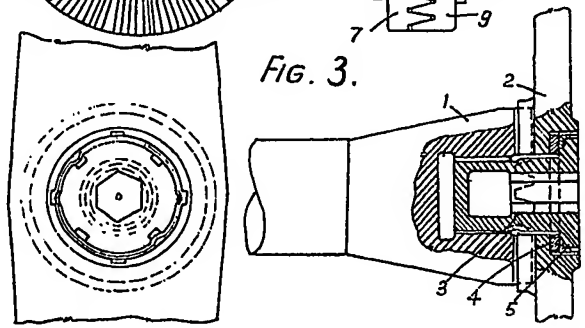


FIG. 4.

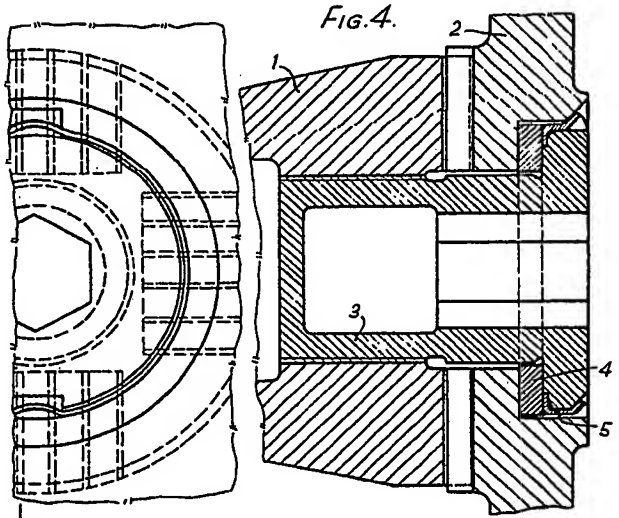


FIG. 5.

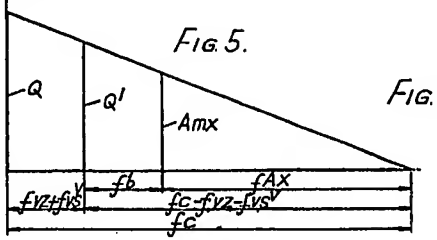


FIG. 6.